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IS 1528-6 (2010): METHODS OF SAMPLING AND PHYSICAL TESTS FOR REFRACTORY MATERIALS, Part 6: DETERMINATION OF PERMANENT LINEAR CHANGE AFTER REHEATING FOR SHAPED INSULATING AND DENSE REFRACTORIES [MTD 15: Refractories]

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भाग 6 अवर्तुल इंसुलेटिंग एवं सघन दुर्गलनीय के पुनःतापन के बाद स्थायी रेखीय परिवर्तन का निर्धारण

(दूसरा पुनरीक्षण)

Indian Standard

METHODS OF SAMPLING AND PHYSICAL TESTS FOR REFRACTORY MATERIALS

PART 6 DETERMINATION OF PERMANENT LINEAR CHANGE AFTER REHEATING FOR SHAPED INSULATING AND DENSE REFRACTORIES

(Second Revision)

ICS 81.080

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NEW DELHI 110002

May 2011 **Price Group 2**

Refractories Sectional Committee, MTD 15

FOREWORD

This Indian Standard (Part 6) (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Refractories Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1962 and subsequently revised in 1974. This standard deals with the determination of permanent linear change after reheating for shaped insulating and dense refractories. Other parts in this series are:

Part 1	Determination of pyrometric cone equivalent (PCE) or softening point
Part 2	Determination of refractoriness under load
Part 3	Determination of spalling resistance
Part 4	Determination of cold crushing strength
Part 5	Method for determination of modulus of rupture at ambient temperature of dense and insulating shaped refractory products
Part 7	Methods of sampling and criteria for conformity
Part 8	Determination of apparent porosity
Part 9	Determination and true density
Part 10	Determination of size of refractory bricks
Part 11	Determination of warpage
Part 12	Method for determination of bulk density and true porosity of shaped insulating refractory products
Part 13	Determination of resistance to carbon monoxide
Part 14	Determination of sieve analysis
Part 15	Method for determination of bulk density, apparent porosity and true porosity of dense shaped refractory products
Part 16	Determination of thermal conductivity according to hot-wire method (parallel)
Part 17	Determination of cold crushing strength of shaped insulating refractory products
Part 18	Determination of creep in compression
Part 19	Determination of thermal expansion
Part 20	Determination of modulus of rupture at elevated temperature
Part 21	Determination of thermal conductivity according to hot-wire method (cross-array)
Part 22	Methods for determination of permeability to gases of dense shaped refractory products

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

METHODS OF SAMPLING AND PHYSICAL TESTS FOR REFRACTORY MATERIALS

PART 6 DETERMINATION OF PERMANENT LINEAR CHANGE AFTER REHEATING FOR SHAPED INSULATING AND DENSE REFRACTORIES

(Second Revision)

1 SCOPE

This standard (Part 6) prescribes the methods of test for determination of permanent linear change of dense and insulating shaped refractories after reheating.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1528	Methods of sampling and physical tests for refractory materials:
(Part 7) : 2010	Methods of sampling and criteria for conformity (*second revision*)
(Part 12) : 2007	Method for determination of bulk density and true porosity of shaped insulating refractory products (*second revision*)
(Part 15) : 2007	Method for determination of bulk density, apparent porosity and true porosity of dense shaped refractory products (*first revision*)
4041 : 2006	Terminology for refractories (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 4041 shall apply.

4 DEFINITION

4.1 Permanent Change in Dimensions on Reheating — The expansion or contraction that remains in a shaped refractory product, that is, heated to a specified temperature for a specified time and then cooled to ambient temperature.

4.2 Insulating Refractory Product — A refractory product having true porosity greater than 45 percent (*v*/*v*) when measured in accordance with IS 1528 (Part 12).

4.3 Dense Shaped Refractory Product — A refractory product having a true porosity of less than 45 percent (*v*/*v*) when measured in accordance with IS 1528 (Part 15).

5 PRINCIPLE

Test pieces prepared out of the bricks are dried. Initial dimension with respect to length in case of Insulating product and initial volume in case of dense shaped product are determined. The test pieces are heated in a furnace at a prescribed rate to a specified temperature, which is maintained for a specified time. After cooling to ambient temperature, test pieces are measured again for final length or final volume and permanent linear change is calculated. For dense shaped products, volume change before and after firing is divided by 3 to arrive at linear change.

6 APPARATUS

6.1 Furnace — Either electric or gas fired, capable of firing the test pieces at the specified rate and of maintaining the test temperature for the required time. The furnace should be equipped with temperature controlling system which shall be able to comply the heating schedule mentioned in **12**.

NOTE — Use of electric furnace is recommended.

6.2 Thermocouple — Thermocouple(s) to measure the temperature.

6.3 Length Measuring Device — Vernier callipers or a dial gauge comparator with an accuracy of 0.1mm.

6.4 Drying Oven — Oven shall be fan assisted and shall have openings, which permit efficient ventilation.

7 TEST PIECES

7.1 Sampling

Unless otherwise agreed, the procedure for sampling may be done according to IS 1528 (Part 7).

7.2 Size of Test Pieces

7.2.1 *For Insulation Bricks*

114 mm × 114 mm × 64 mm or 76 mm, that is, half of standard brick.

7.2.2 *For Dense Shaped Refractory Brick*

50 mm × 50 mm × 60 mm ± 2 mm sized rectangular prisms or 50 mm diameter and 60 ± 2 mm height cylinders.

7.2.3 Alternatively, wherever above sizes are not possible to cut, maximum size keeping as many original faces as possible of the sample shall be used.

NOTE — In cutting, care should be taken that the structure of the brick is not damaged. Cutting by cutting off wheel is recommended.

8 PROCEDURE

8.1 Dry the test specimen in a drying oven at 110 ± 5°C to constant mass.

8.2 Measurement of Test Pieces

8.2.1 *For Insulating Refractory Shaped Product*

Calibrated length measuring device shall be used for measurement of dimensions. Make measurements on each test piece to the nearest 0.2 mm of the distance L_o between the opposite faces nominally 114 mm apart. Make two of these measurements parallel to the centrelines (*EF* and *GH* in Fig. 1) of the top and bottom faces of the test pieces, 15 mm from the edges of those faces, and two parallel to the centrelines (*AB* and *CD*) of the front and rear faces of the test pieces 15 mm from the edges of those faces. Mark the position of the measurements with refractory paint.

8.2.2 *For Dense Shaped Refractory Product*

Determine the volume of each test piece by the method laid down in IS 1528 (Part 15).

9 MOUNTING OF TEST PIECES IN THE FURNACE

Place the test pieces in the furnace as given below:

a) *For Insulation Bricks* — Place each sample on a 114 mm × 76 mm or 114 mm × 64 mm face

b) *For Dense Shaped Refractory Bricks* — Each resting on its 50 mm × 50 mm faces for cube samples and on one of the faces for cylindrical samples.

The samples shall be protected from direct radiation in an electrically heated furnace or from the flame of the gas burner in a gas fired furnace. Do not superimpose test pieces one on another. To allow free circulation of the hot gases, the test pieces shall be separated from each other by a distance of not less than 20 mm and shall be not nearer than 50 mm to the wall of the furnace to avoid direct heat impingement. The test pieces shall be placed in the furnace on bricks of 30 to 65 mm thick preferably of same quality.

10 TEST TEMPERATURE

Unless otherwise agreed, the test temperature shall be 800°C or a higher temperature in multiples of 50°C.

11 TEMPERATURE MEASUREMENT

Thermocouple shall be placed away from the walls of the furnace, away from the heaters so as not to be in contact with any flames or direct heating from elements.

12 HEATING

Raise the temperature in the furnace at one of the following rates:

a) For test temperatures up to 1 250°C:
   1) From ambient temperature up to 50°C below the test temperature: between 5 to 10°C/min,
   2) For the last 50°C: between 1 to 5°C/min.

b) For test temperatures above 1 250°C:
   1) From ambient temperature up to 1 200°C : between 5 to 10°C/min.
   2) From 1 200°C up to 50°C below the test temperature: between 2 to 5°C/min.
   3) For the last 50°C: between 1 to 5°C /min.

13 MAINTENANCE OF TEST TEMPERATURE

Maintain the temperature recorded on thermocouple(s) to within ±10°C of the test temperature. Hold at the test temperature for a period of 12 h for Insulating shapes and for dense shaped refractory bricks for a period of 5 h.

Any other holding period at test temperature may be followed as per mutual agreement of the manufacturer and the purchaser.

14 COOLING

Switch off the furnace after reaching and holding at the test temperature. Allow it to cool at its natural rate, the test pieces being allowed to cool in the furnace.

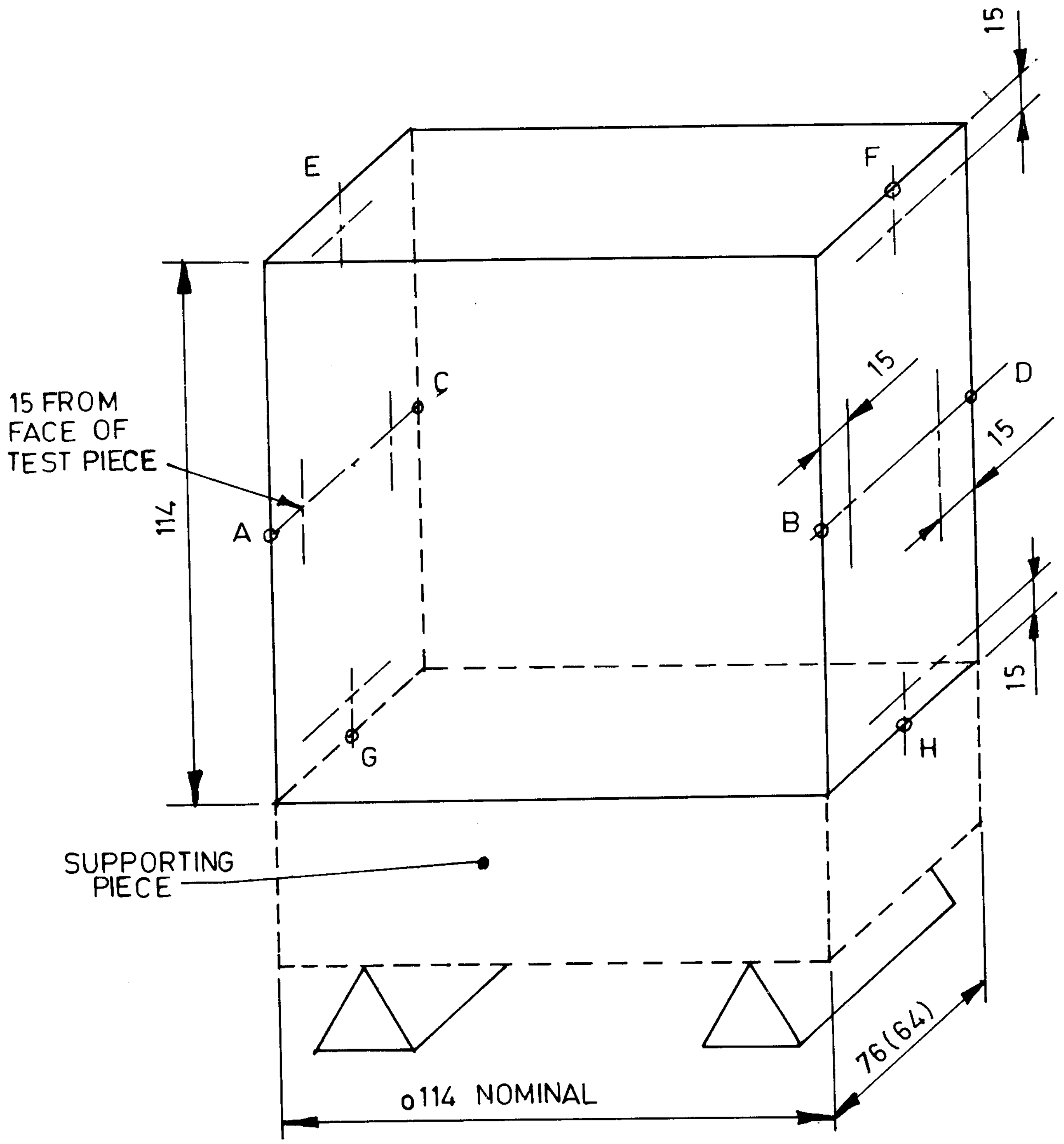

FIG. 1 POSITION OF MEASUREMENTS AND MOUNTING OF THE TEST PIECES IN THE FURNACE

15 MEASUREMENT OF TEST PIECES AFTER FIRING

First examine the test pieces, noting particularly any blisters or accretions produced during firing.

15.1 Linear Measurement for Insulating Brick Samples

Measure the distance between the two opposite faces of each test piece as described in **8.2**. If any of the measuring points might be affected by such a defect, measure at the nearest point unaffected. If necessary, rotate the test piece to avoid contact between defects.

15.2 Volume Measurement

Measure the volume of the test piece by the same method as used in **8.2.2**.

16 EXPRESSION OF RESULTS

For Insulation refractory quality, calculate the change in the relevant length, ΔL as a percentage of original value L_o, that is, $100 \times \Delta L / L_o$. Calculate the change in length for each measuring point.

For dense shaped refractory sample, calculate the change in relevant volume, ΔV as a percentage of original volume V_o, that is, $100 \times \Delta V/V_o$. Divide the percentage change in volume by 3 to arrive at the linear change.

Report increase in length as positive (+) and decrease as negative (–).

17 TEST REPORT

The test report shall include the following:

a) Description of the material tested,
b) Number of items tested,
c) Number of test pieces per item or brick,
d) Type of length measuring device used,
e) Type of furnace used,
f) The heating schedule used,
g) Test temperature,
h) Period of the actual holding time at test temperature, and
j) Appearance of test pieces after firing.

18 ACCEPTANCE AND CONFORMITY

The procedure for acceptance and conformity shall be as laid down in IS 1528 (Part 7).

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Amendments Issued Since Publication

Amendment No.	Date of Issue	Text Affected

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